FIG. 1
(prior art)

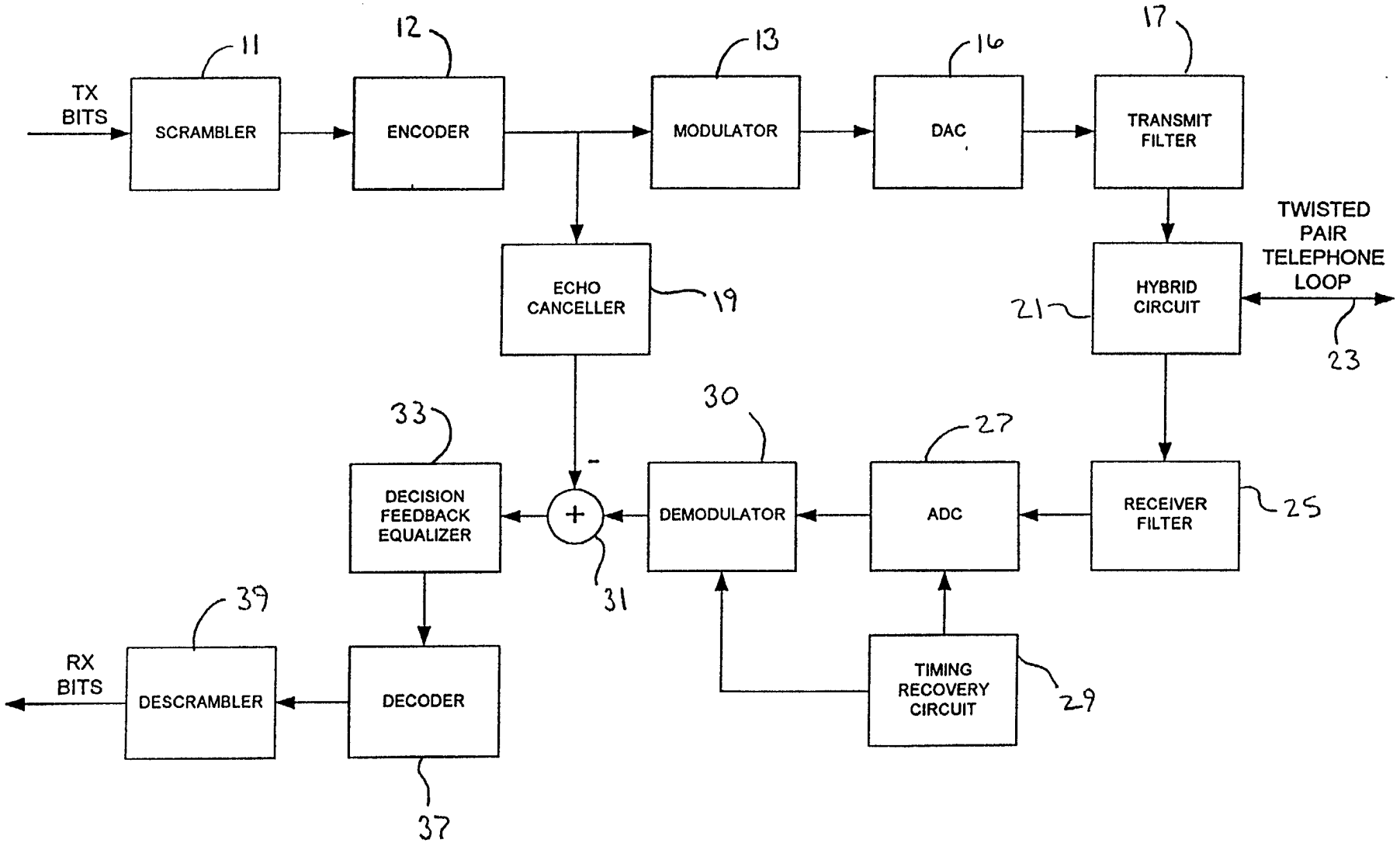
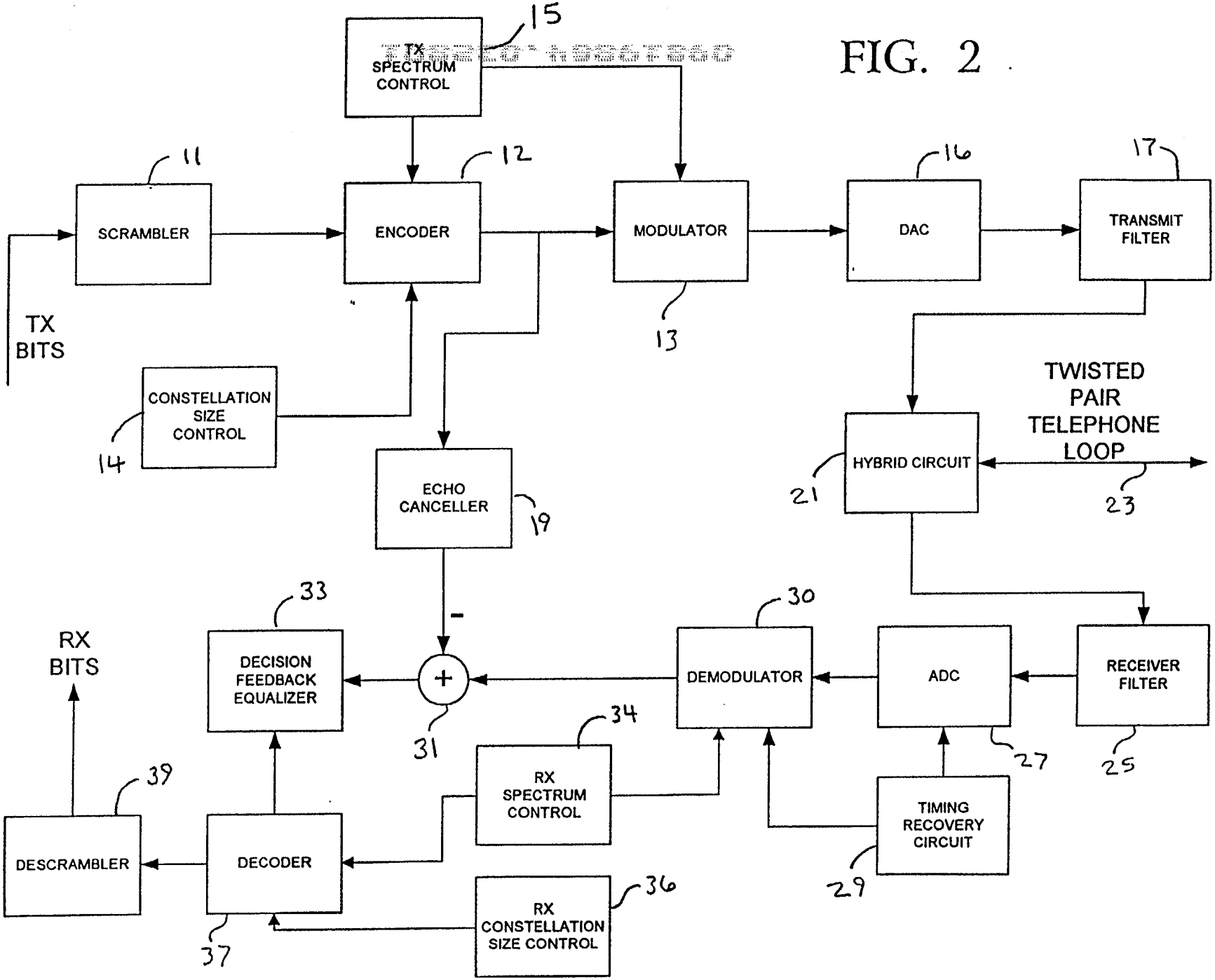


FIG. 2


TX SPECTRUM CONTROL
15
SCRAMBLER
11
ENCODER
12
MODULATOR
13
DAC
16
TRANSMIT FILTER
17
TX BITS
CONSTELLATION SIZE CONTROL
14
ECHO CANCELLER
19
HYBRID CIRCUIT
21
TWISTED PAIR TELEPHONE LOOP
23
RX BITS
DECISION FEEDBACK EQUALIZER
33
DEMODULATOR
30
ADC
RECEIVER FILTER
25
27
31
RX SPECTRUM CONTROL
34
TIMING RECOVERY CIRCUIT
29
DESCRAMBLER
39
DECODER
37
RX CONSTELLATION SIZE CONTROL
36

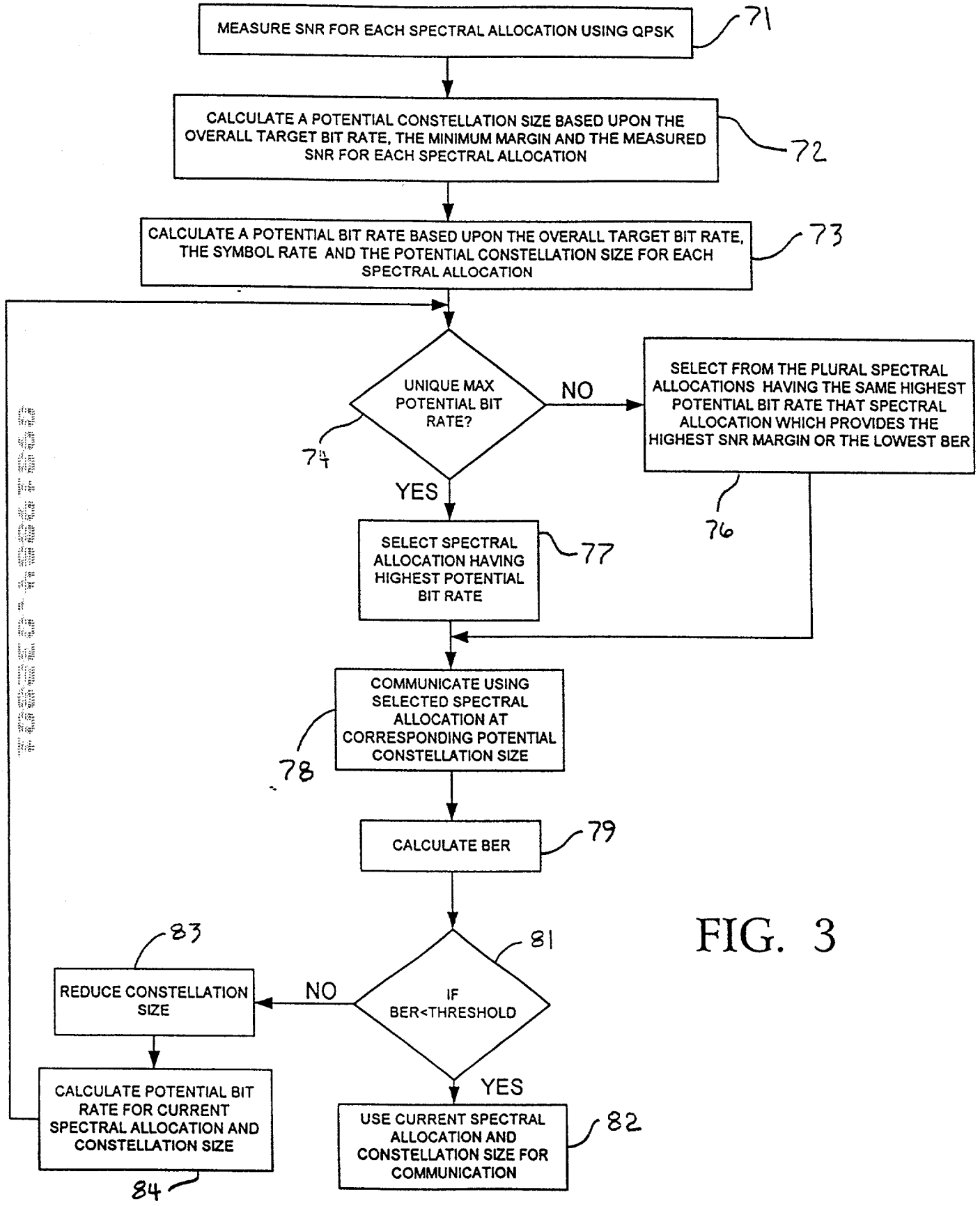
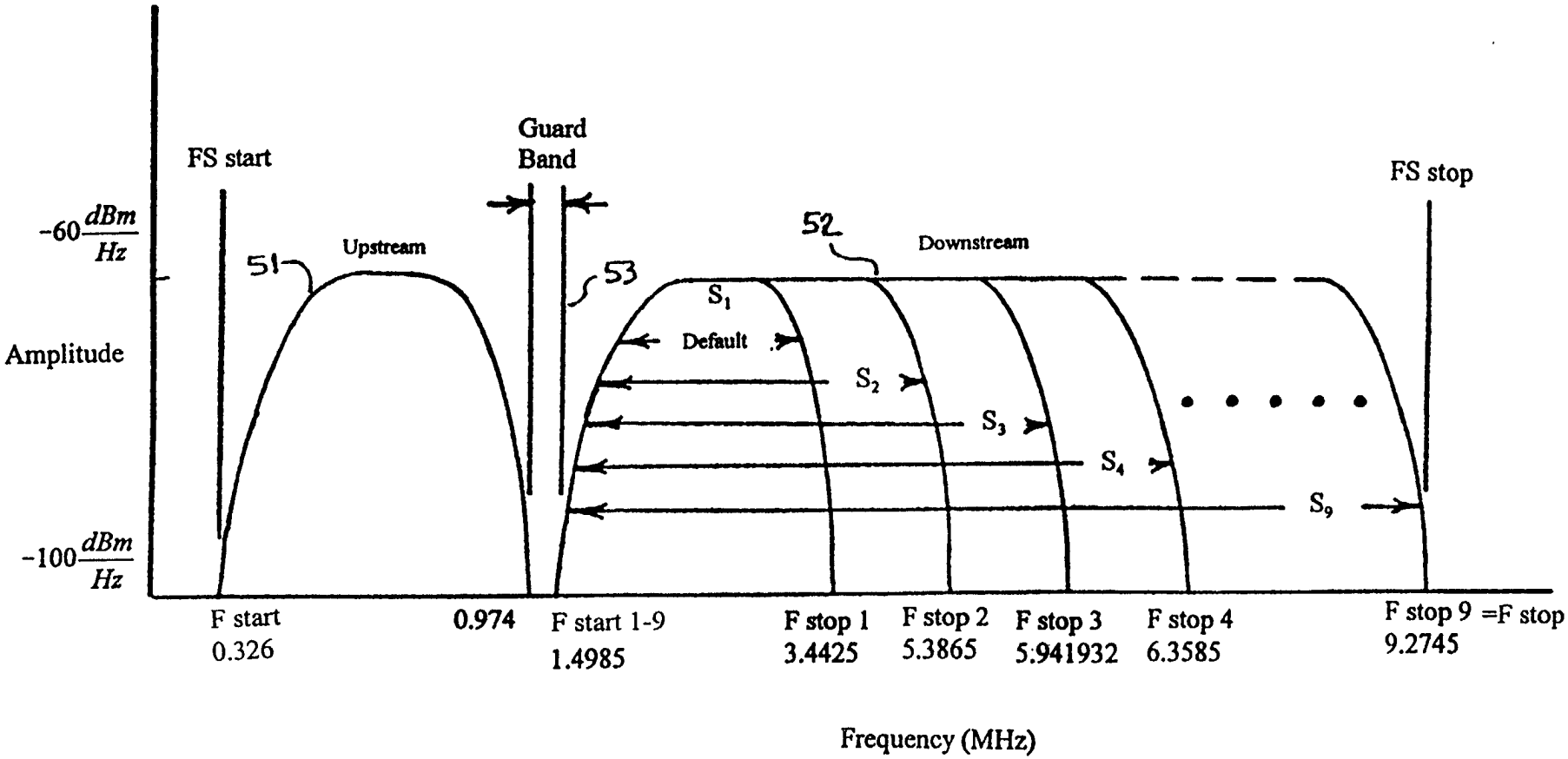

MEASURE SNR FOR EACH SPECTRAL ALLOCATION USING QPSK
71
CALCULATE A POTENTIAL CONSTELLATION SIZE BASED UPON THE OVERALL TARGET BIT RATE, THE MINIMUM MARGIN AND THE MEASURED SNR FOR EACH SPECTRAL ALLOCATION
72
CALCULATE A POTENTIAL BIT RATE BASED UPON THE OVERALL TARGET BIT RATE, THE SYMBOL RATE AND THE POTENTIAL CONSTELLATION SIZE FOR EACH SPECTRAL ALLOCATION
73
UNIQUE MAX POTENTIAL BIT RATE?
74
NO
SELECT FROM THE PLURAL SPECTRAL ALLOCATIONS HAVING THE SAME HIGHEST POTENTIAL BIT RATE THAT SPECTRAL ALLOCATION WHICH PROVIDES THE HIGHEST SNR MARGIN OR THE LOWEST BER
76
YES
SELECT SPECTRAL ALLOCATION HAVING HIGHEST POTENTIAL BIT RATE
77
COMMUNICATE USING SELECTED SPECTRAL ALLOCATION AT CORRESPONDING POTENTIAL CONSTELLATION SIZE
78
CALCULATE BER
79
IF BER<THRESHOLD
81
NO
REDUCE CONSTELLATION SIZE
83
CALCULATE POTENTIAL BIT RATE FOR CURRENT SPECTRAL ALLOCATION AND CONSTELLATION SIZE
84
YES
USE CURRENT SPECTRAL ALLOCATION AND CONSTELLATION SIZE FOR COMMUNICATION
82

FIG. 3

FIG. 4


FS start
Guard Band
FS stop
-60 dBm/Hz
-100 dBm/Hz
Amplitude
51
Upstream
52
Downstream
53
S1
Default
S2
S3
S4
S9
F start 0.326
0.974
F start 1-9 1.4985
F stop 1 3.4425
F stop 2 5.3865
F stop 3 5.941932
F stop 4 6.3585
F stop 9 =F stop 9.2745
Frequency (MHz)

Symbol Rate (Bandwidth)	SNR (measured)	Potential Constellation (Assuming 3 dB SNR Margin and Overall Target Rate = 25.92 Mbps)	Potential Bit Rate
S_1 = 1.62 Mbaud (Default)	40 dB	256	12.96 Mbps
S_2 = 3.24 Mbaud	38 dB	~~256~~[1] 128	~~25.92~~[1] 22.68 Mbps
S_3 = 3.70286 Mbaud	34 dB	~~128~~[2] 64	~~25.92~~[2] 22.21716 Mbps
S_4 = 4.05 Mbaud	31 dB	128	25.92[3]
S_5 = 4.32 Mbaud	28 dB	64	25.92
S_6 = 4.86 Mbaud	27 dB	32	24.3
S_7 = 5.184 Mbaud	26 dB	32	25.92[4]
S_8 = 5.67 Mbaud	22 dB	16	22.68
S_9 = 6.48 Mbaud	16 dB	4	12.96

NOTE: FEC payload percentage = 1 (No FEC)

(1) BER test failed.

(2) QAM-128 initially selected instead of QAM-256 due to value of overall target rate. BER test at QAM-128 subsequently failed.

(3) Potential bit rate › target rate; target rate entered in table, and FEC payload percentage optionally reduced.

(4) S_7 ultimately used for communication.

FIG. 5

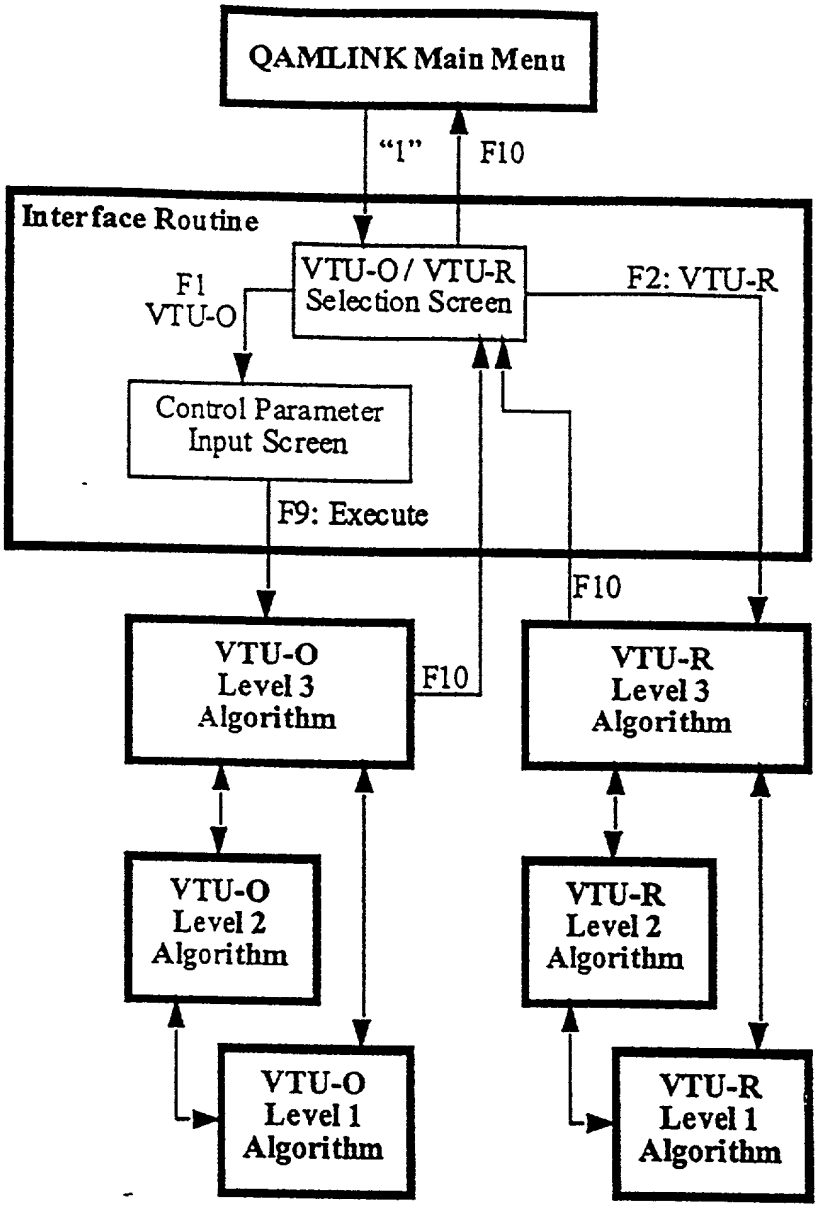

QAMLINK Main Menu
"1"
F10
Interface Routine
VTU-O / VTU-R
Selection Screen
F1
VTU-O
F2: VTU-R
Control Parameter
Input Screen
F9: Execute
F10
VTU-O
Level 3
Algorithm
F10
VTU-R
Level 3
Algorithm
VTU-O
Level 2
Algorithm
VTU-R
Level 2
Algorithm
VTU-O
Level 1
Algorithm
VTU-R
Level 1
Algorithm

FIG. 6

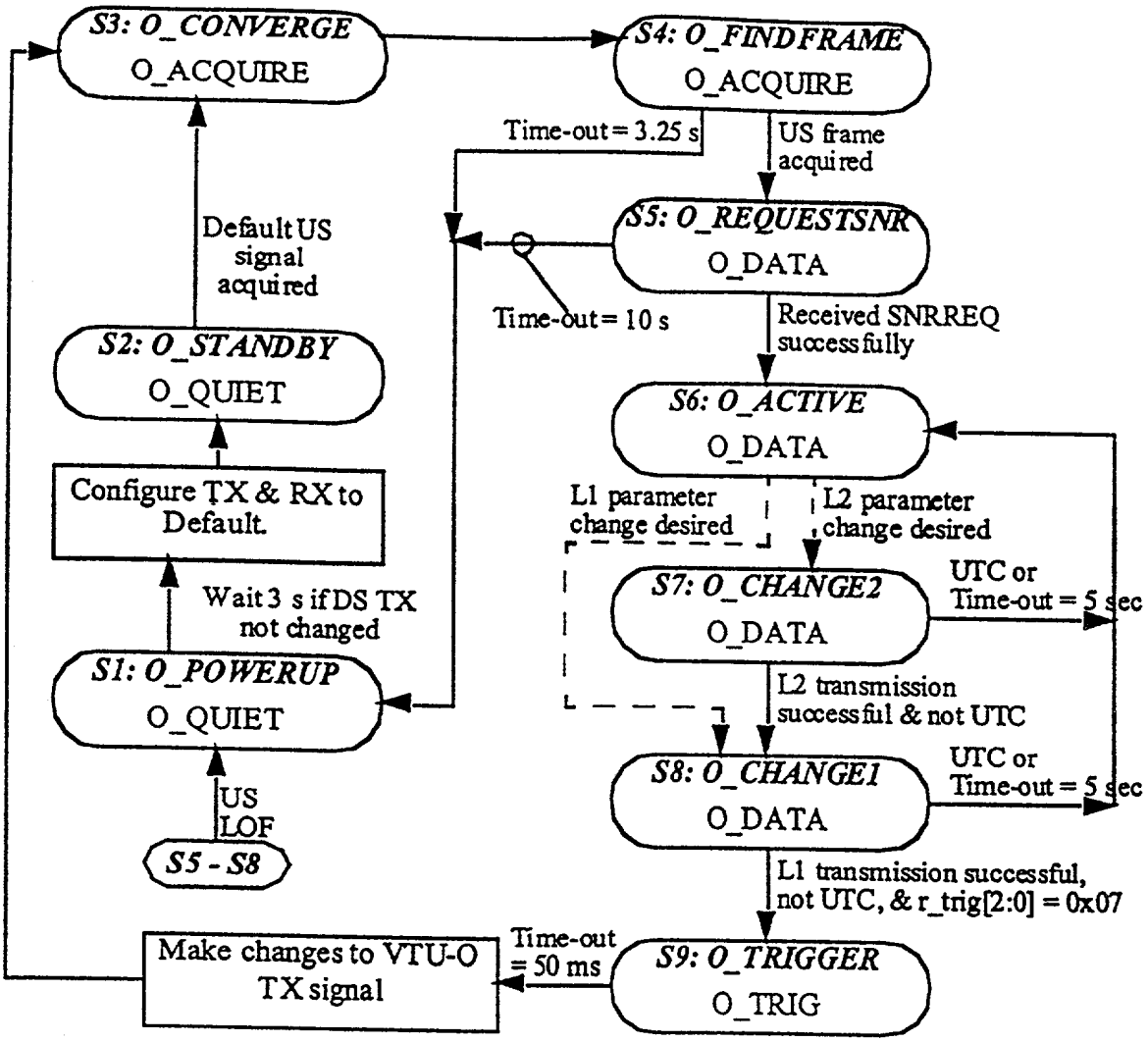

S3: O_CONVERGE
O_ACQUIRE
S4: O_FINDFRAME
O_ACQUIRE
Time-out = 3.25 s
US frame acquired
S5: O_REQUESTSNR
O_DATA
Time-out = 10 s
Received SNRREQ successfully
Default US signal acquired
S2: O_STANDBY
O_QUIET
S6: O_ACTIVE
O_DATA
Configure TX & RX to Default.
L1 parameter change desired
L2 parameter change desired
Wait 3 s if DS TX not changed
S7: O_CHANGE2
O_DATA
UTC or Time-out = 5 sec
S1: O_POWERUP
O_QUIET
L2 transmission successful & not UTC
S8: O_CHANGE1
O_DATA
UTC or Time-out = 5 sec
US LOF
S5 - S8
L1 transmission successful, not UTC, & r_trig[2:0] = 0x07
Make changes to VTU-O TX signal
Time-out = 50 ms
S9: O_TRIGGER
O_TRIG

FIG. 7

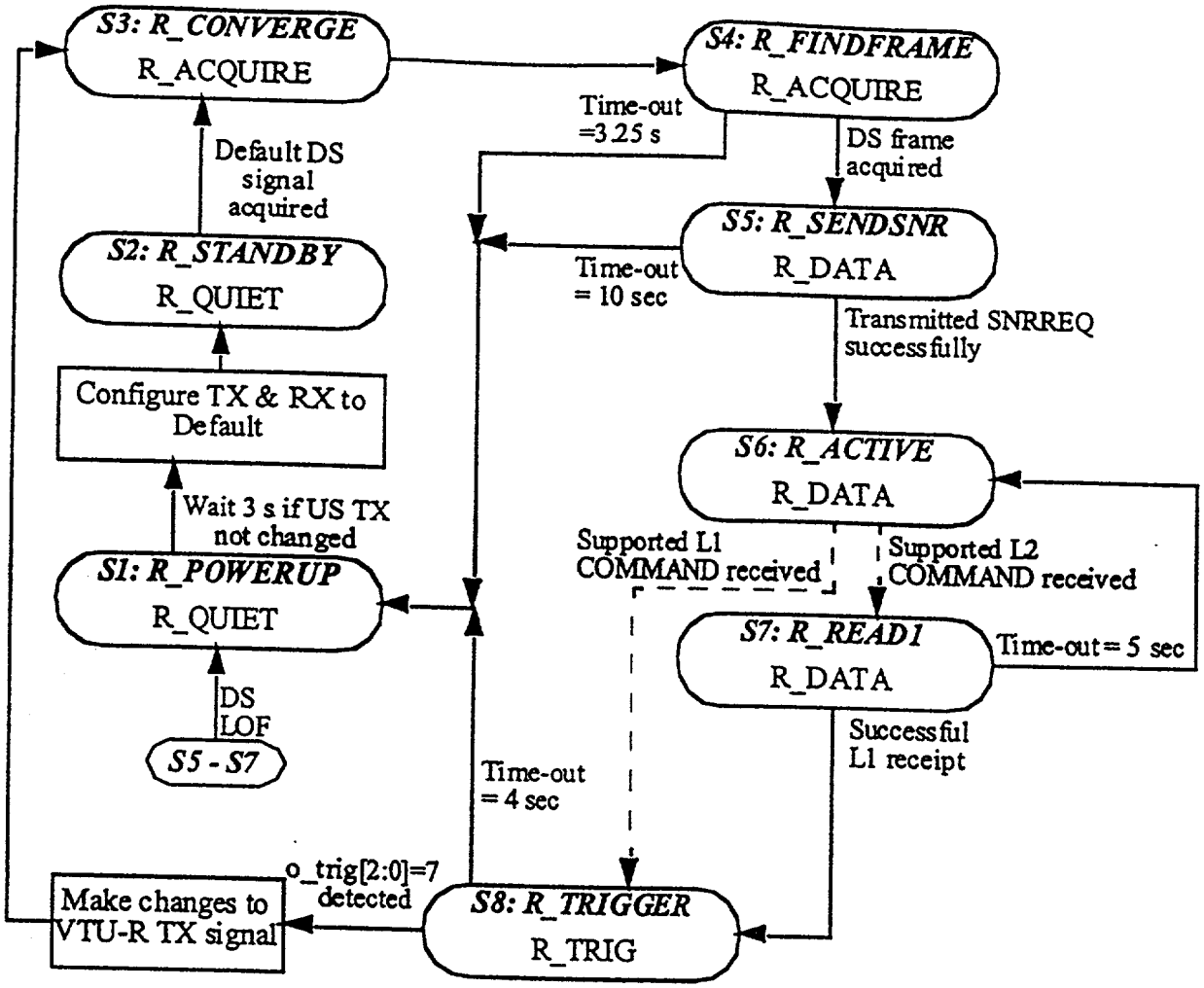

S3: R_CONVERGE
R_ACQUIRE
S4: R_FINDFRAME
R_ACQUIRE
Time-out
=3.25 s
DS frame
acquired
Default DS
signal
acquired
S2: R_STANDBY
R_QUIET
S5: R_SENDSNR
R_DATA
Time-out
= 10 sec
Transmitted SNRREQ
successfully
Configure TX & RX to
Default
S6: R_ACTIVE
R_DATA
Wait 3 s if US TX
not changed
Supported L1
COMMAND received
Supported L2
COMMAND received
S1: R_POWERUP
R_QUIET
S7: R_READ1
R_DATA
Time-out = 5 sec
DS
LOF
S5 - S7
Successful
L1 receipt
Time-out
= 4 sec
o_trig[2:0]=7
detected
Make changes to
VTU-R TX signal
S8: R_TRIGGER
R_TRIG

FIG. 8

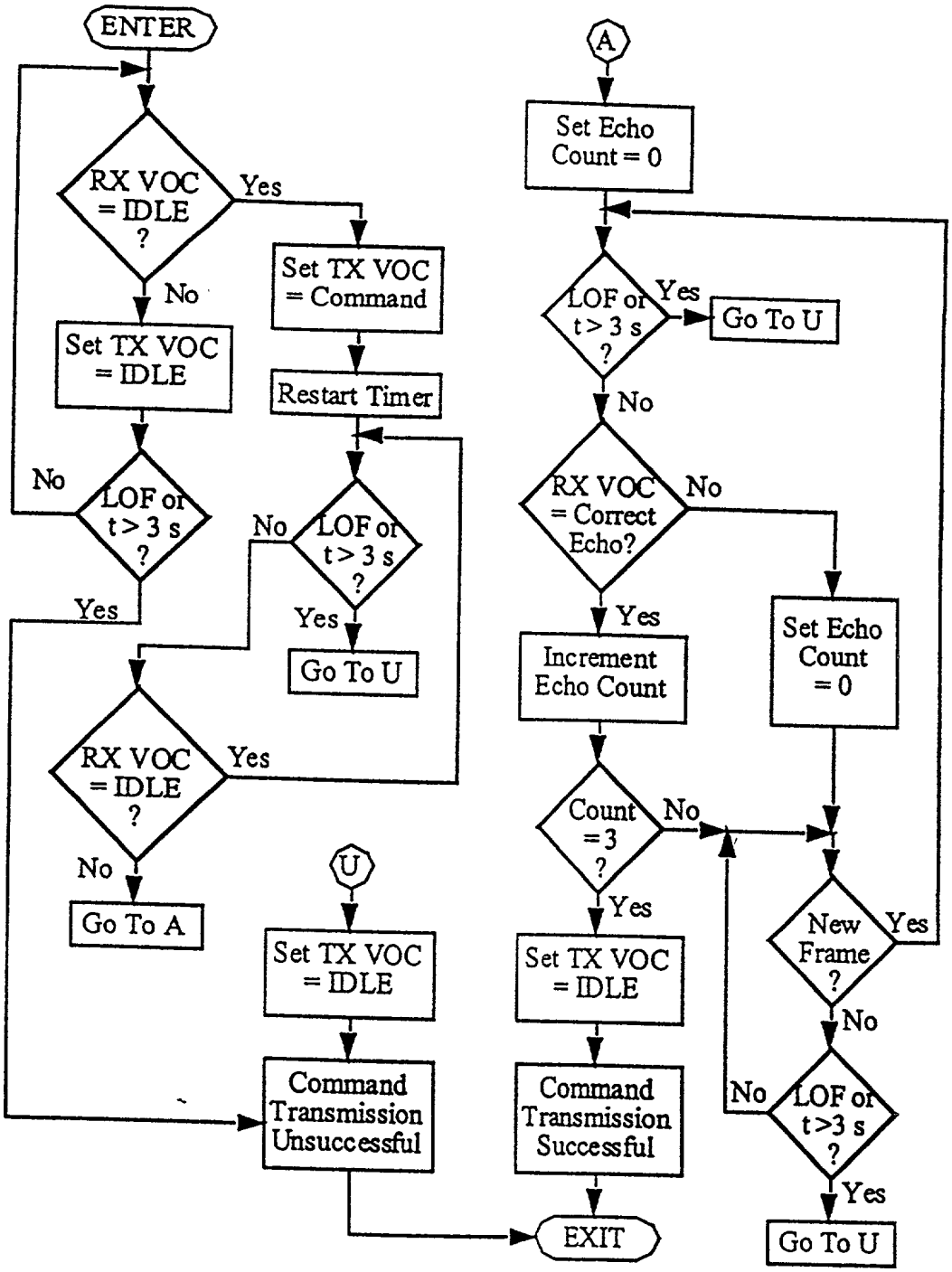

ENTER
RX VOC = IDLE ?
Yes
No
Set TX VOC = Command
Set TX VOC = IDLE
Restart Timer
No
LOF or t > 3 s ?
No
LOF or t > 3 s ?
Yes
Yes
Go To U
RX VOC = IDLE ?
Yes
No
Go To A
U
Set TX VOC = IDLE
Command Transmission Unsuccessful
EXIT
A
Set Echo Count = 0
LOF or t > 3 s ?
Yes
Go To U
No
RX VOC = Correct Echo?
No
Yes
Increment Echo Count
Set Echo Count = 0
Count = 3 ?
No
Yes
Set TX VOC = IDLE
Command Transmission Successful
New Frame ?
Yes
No
No
LOF or t > 3 s ?
Yes
Go To U

FIG. 9

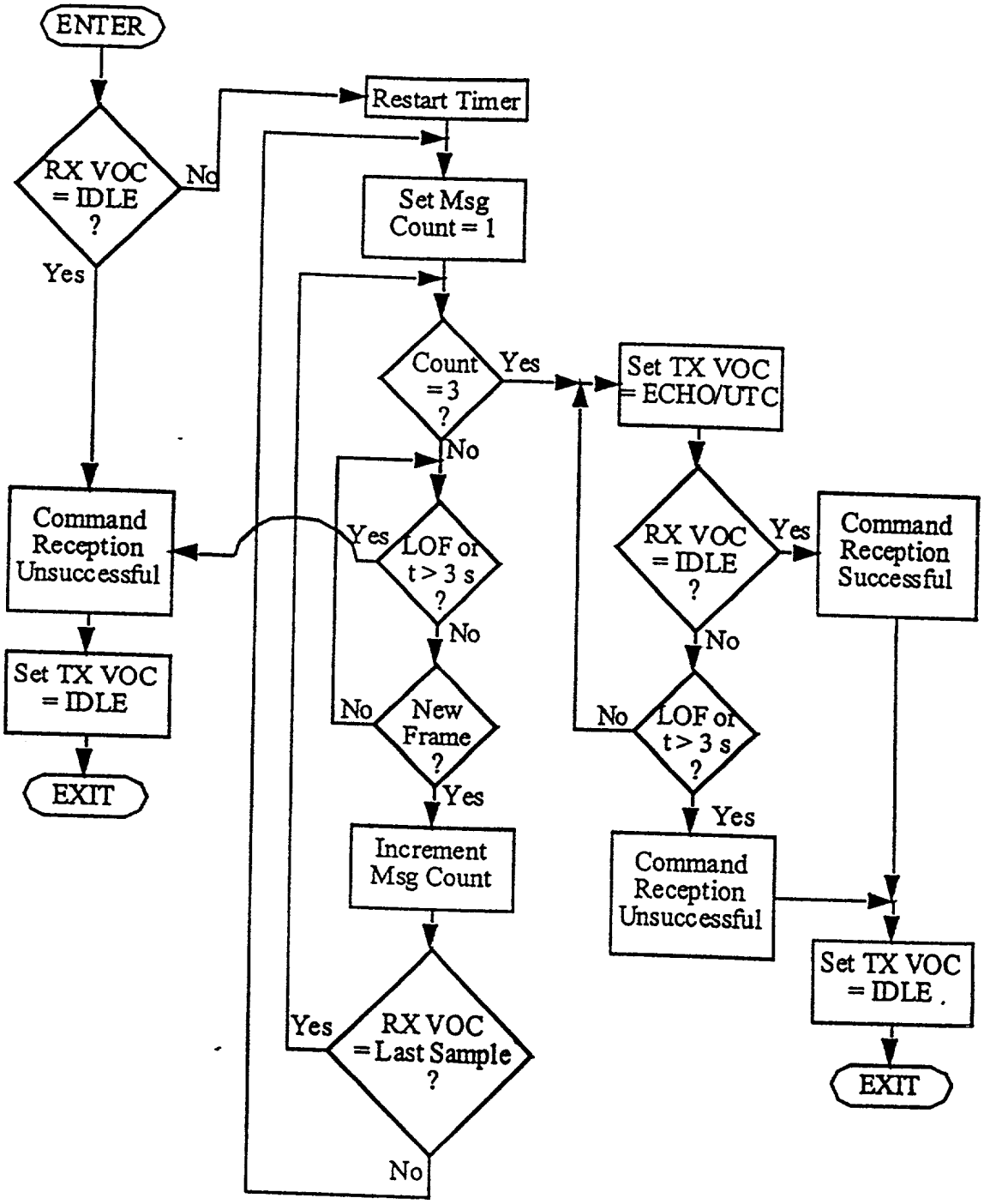
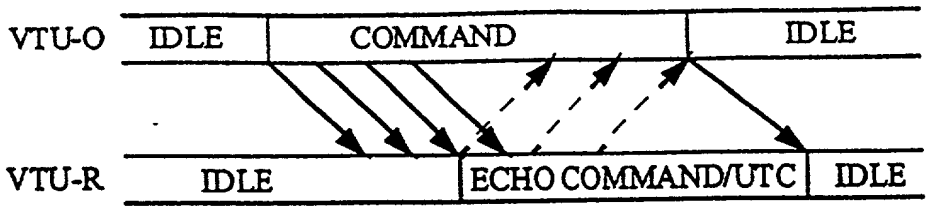

ENTER
RX VOC = IDLE ?
No
Yes
Restart Timer
Set Msg Count = 1
Count = 3 ?
Yes
No
Set TX VOC = ECHO/UTC
Command Reception Unsuccessful
Yes
LOF or t > 3 s ?
No
Set TX VOC = IDLE
EXIT
No
New Frame ?
Yes
Increment Msg Count
Yes
RX VOC = Last Sample ?
No
RX VOC = IDLE ?
Yes
Command Reception Successful
No
No
LOF or t > 3 s ?
Yes
Command Reception Unsuccessful
Set TX VOC = IDLE
EXIT

FIG. 10

FIG. 11


VTU-O
IDLE
COMMAND
IDLE
VTU-R
IDLE
ECHO COMMAND/UTC
IDLE

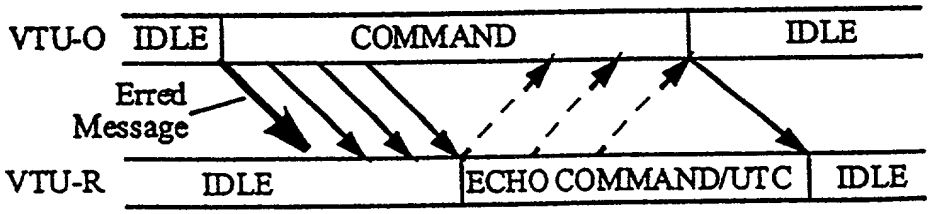

VTU-O
IDLE
COMMAND
IDLE
Erred
Message
VTU-R
IDLE
ECHO COMMAND/UTC
IDLE

FIG. 12

Received VOC COMMAND	ECHO Opcode	ECHO Data
D_NOM (0x34)	D_NOM (0x34)	Same as COMMAND data
D_CONST (0x28)	D_CONST (0x28)	Same as COMMAND data
U_CONST (0x98)	U_CONST (0x98)	Same as COMMAND data
SNRREQ (0x01)	SNRREQ (0x01)	Downstream Avg. SNR
CORERREQ (0x05)	CORERREQ (0x05)	Number of Reed-Solomon corrected errors
UCERREQ (0x07)	UCERREQ (0x07)	Number of uncorrectable Reed Solomon blocks
Else	UTC (0xF0)	Same as COMMAND data

FIG. 13

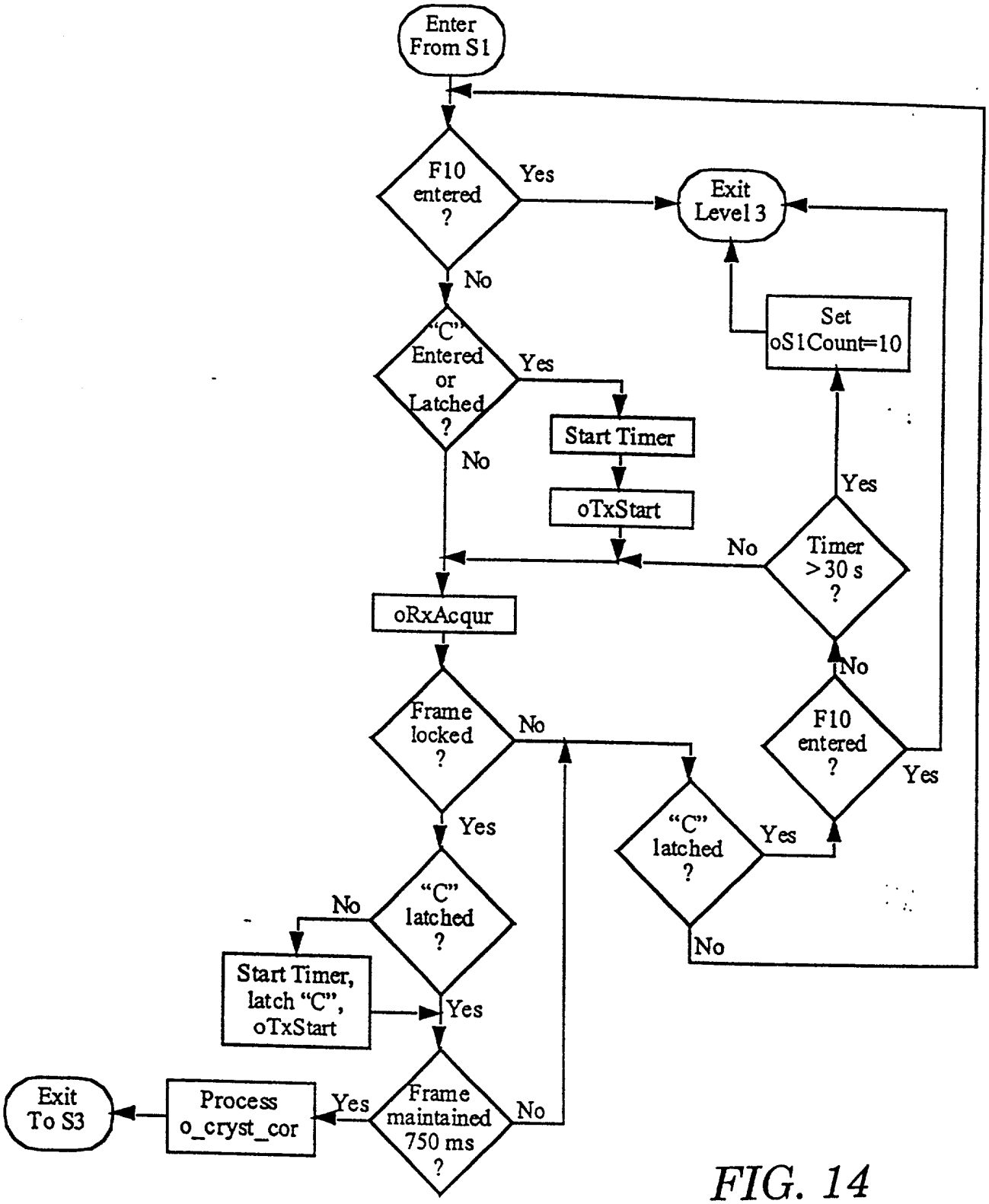

Enter From S1
F10 entered ?
Yes
Exit Level 3
No
"C" Entered or Latched ?
Yes
Set oS1Count=10
Start Timer
No
oTxStart
Yes
No
Timer >30 s ?
oRxAcqur
No
Frame locked ?
No
F10 entered ?
Yes
Yes
"C" latched ?
Yes
No
"C" latched ?
No
Start Timer, latch "C", oTxStart
Yes
Exit To S3
Process o_cryst_cor
Yes
Frame maintained 750 ms ?
No

FIG. 14

FIG. 15

Parameter	Valid Values
Upstream Symbol Rate	Any integer value between 405E3 baud and 810E3 baud
Upstream Constellation	4, 8, 16, 32, 64, 128, 256
Upstream Interleaving Depth	Any integer between 1 and 16 (up to 29 for reduced codeword sizes)
Upstream Transmit PSD Level	Any integer between 0 and 63 (PSD[dBm/Hz] = Value – 100)
Upstream Center Frequency	Range depends on symbol rate, granularity = 1 Hz
Upstream Frame Structure	Includes sync word, uncoded control, coded control, and Reed Solomon code word, all of programmable size
u_nom	0x0003
Downstream Symbol Rate	Any integer value between 1.62E6 baud and 12.96E6 baud
Downstream Constellation	4, 8, 16, 32, 64, 128, 256
Downstream Interleaving Depth	Any integer between 1 and 16 (up to 29 for reduced codeword sizes)
Downstream Transmit PSD Level	Any integer between 0 and 63 (PSD[dBm/Hz] = Value – 100
Downstream Center Frequency	Range depends on symbol rate, granularity = 1 Hz
Downstream Frame Structure	Includes sync word, uncoded control, coded control, and Reed Solomon code word, all of programmable size
d_nom	0x0000 through 0x000C and 0x0081 through 0x0083.

u_nom Value	Upstream Channel Symbol Rate	Upstream Channel Center Freq.
0x0000	Not a nominal value	Not a nominal value
0x0003	0.540 Mbaud	0.650 MHz

FIG. 16

d_nom Value	Downstream Channel Symbol Rate	Downstream Channel Center Freq.
0x0000	Not a nominal value	Not a nominal value
0x0001	1.620 Mbaud	3.420 MHz
0x0002	1.620 Mbaud	2.960 MHz
0x0003	3.240 Mbaud	3.950 MHz
0x0004	3.240 Mbaud	3.4425 MHz
0x0005	4.860 Mbaud	4.940 MHz
0x0006	4.860 Mbaud	4.4145 MHz
0x0007	6.480 Mbaud	5.920 MHz
0x0008	6.480 Mbaud	5.3865 MHz
0x0009	9.720 Mbaud	8.240 MHz
0x000A	9.720 Mbaud	7.331 MHz
0x000B	12.960 Mbaud	10.180 MHz
0x000C	12.960 Mbaud	9.275 MHz
0x0081	1.620 Mbaud	2.4705 MHz
0x0082	3.70286 Mbaud	3.720216 MHz
0x0083 –	4.05 Mbaud	3.9285 MHz
0x0084	5.67 Mbaud	4.9005 MHz
0x0085	4.32 Mbaud	4.0905 MHz
0x0086	5.184 Mbaud	4.6089 MHz

FIG. 17

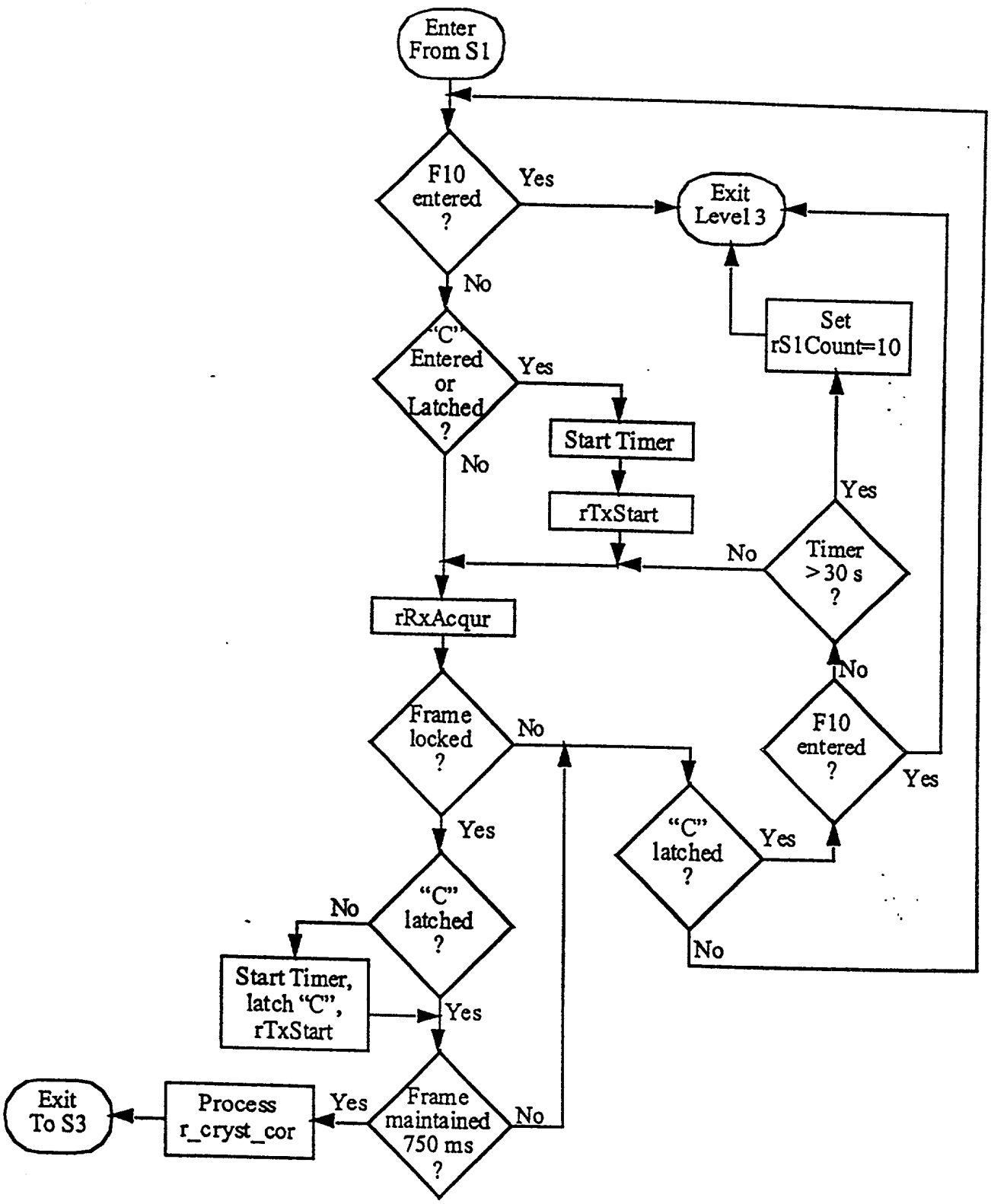

Enter From S1
F10 entered ?
Yes
Exit Level 3
No
"C" Entered or Latched ?
Yes
Set rS1Count=10
Start Timer
rTxStart
No
Yes
Timer >30 s ?
No
rRxAcqur
Frame locked ?
No
No
F10 entered ?
Yes
Yes
"C" latched ?
Yes
"C" latched ?
No
No
Start Timer, latch "C", rTxStart
Yes
Exit To S3
Process r_cryst_cor
Yes
Frame maintained 750 ms ?
No

FIG. 18

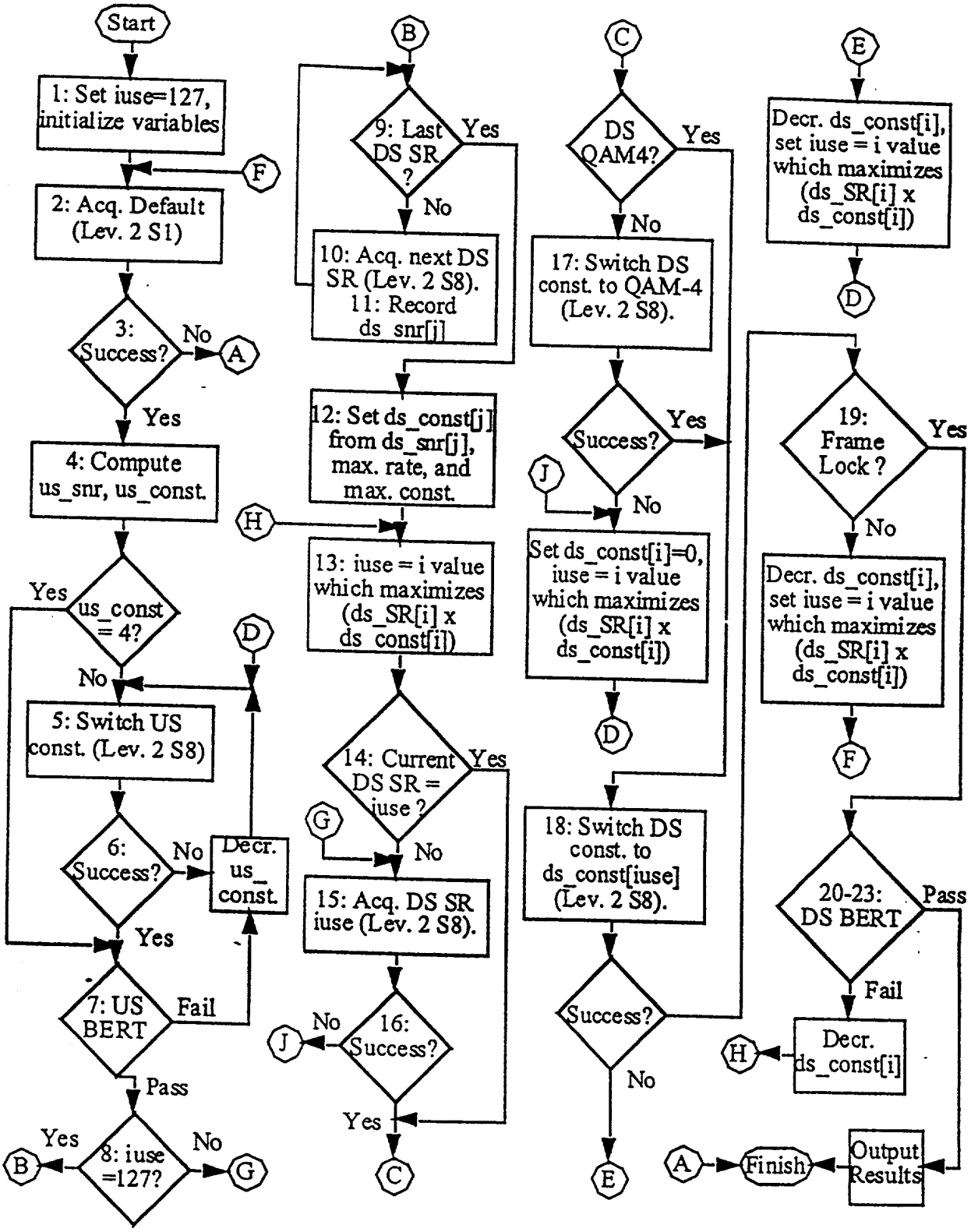

Start
1: Set iuse=127, initialize variables
2: Acq. Default (Lev. 2 S1)
3: Success?
No
Yes
4: Compute us_snr, us_const.
us_const = 4?
Yes
No
5: Switch US const. (Lev. 2 S8)
6: Success?
No
Decr. us_ const.
Yes
7: US BERT
Fail
Pass
8: iuse =127?
Yes
No
9: Last DS SR ?
Yes
No
10: Acq. next DS SR (Lev. 2 S8).
11: Record ds_snr[j]
12: Set ds_const[j] from ds_snr[j], max. rate, and max. const.
13: iuse = i value which maximizes (ds_SR[i] x ds_const[i])
14: Current DS SR = iuse ?
Yes
No
15: Acq. DS SR iuse (Lev. 2 S8).
16: Success?
No
Yes
DS QAM4?
Yes
No
17: Switch DS const. to QAM-4 (Lev. 2 S8).
Success?
Yes
No
Set ds_const[i]=0, iuse = i value which maximizes (ds_SR[i] x ds_const[i])
18: Switch DS const. to ds_const[iuse] (Lev. 2 S8).
Success?
No
Decr. ds_const[i], set iuse = i value which maximizes (ds_SR[i] x ds_const[i])
19: Frame Lock ?
Yes
No
Decr. ds_const[i], set iuse = i value which maximizes (ds_SR[i] x ds_const[i])
20-23: DS BERT
Pass
Fail
Decr. ds_const[i]
Finish
Output Results
A
B
C
D
E
F
G
H
J

FIG. 19

FIG. 20

Average Upstream SNR – Upstream Margin	Upstream Constellation Value
Less than 19 dB	(QAM-4)
Between 19 dB and 22 dB	(QAM-16)
Between 22 dB and 25 dB	(QAM-32)
Between 25 dB and 28 dB	(QAM-64)
Between 28 dB and 31 dB	(QAM-128)
Greater than 31 dB	(QAM-256)

SNR – Downstream Margin	Constellation
Less than 10 dB	None
Between 10 dB and 19 dB	(QAM-4)
Between 19 dB and 22 dB	(QAM-16)
Between 22 dB and 25 dB	(QAM-32)
Between 25 dB and 28 dB	(QAM-64)
Between 28 dB and 31 dB	(QAM-128)
Greater than 31 dB	(QAM-256)

FIG. 21

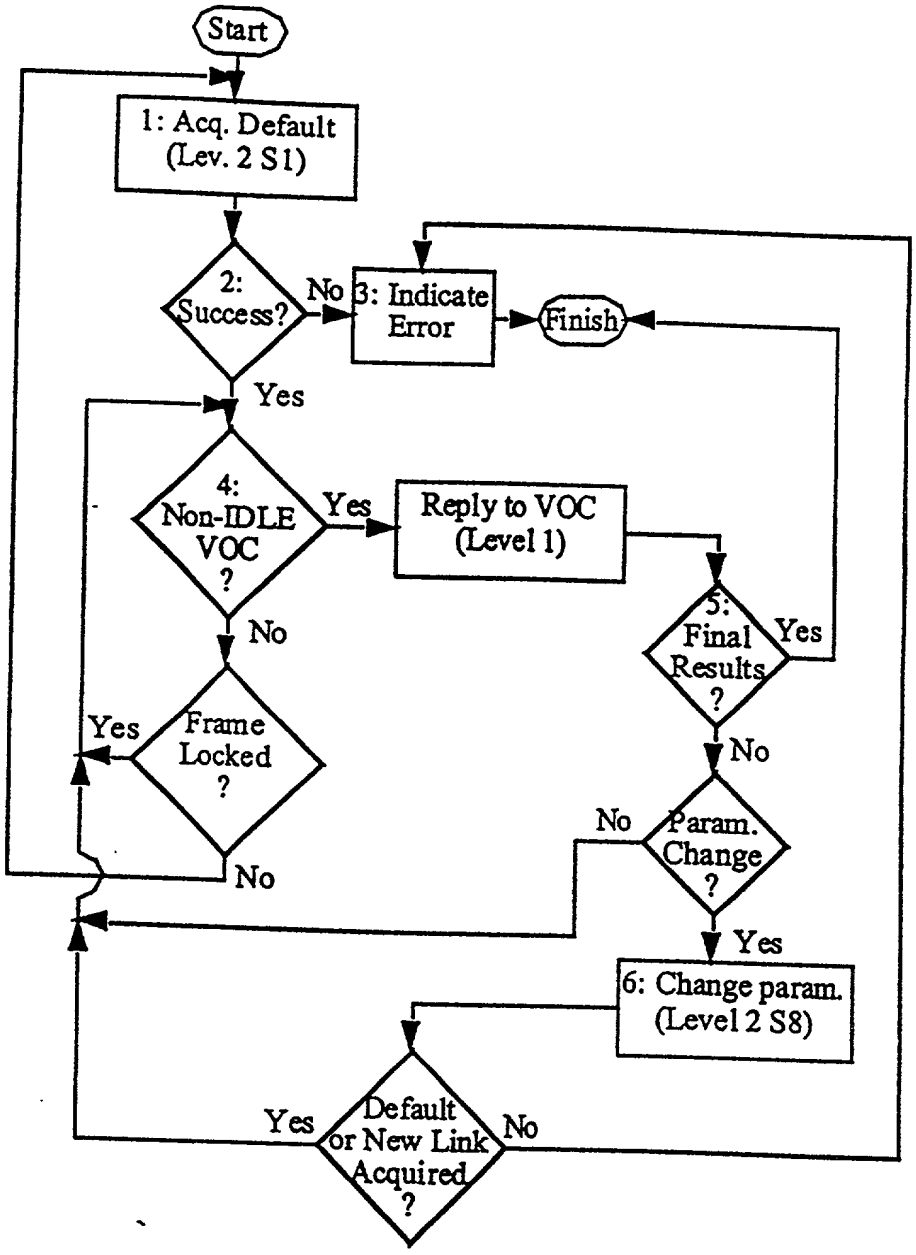

Start
1: Acq. Default (Lev. 2 S1)
2: Success?
No
3: Indicate Error
Finish
Yes
4: Non-IDLE VOC ?
Yes
Reply to VOC (Level 1)
No
5: Final Results ?
Yes
Yes
Frame Locked ?
No
No
Param. Change ?
Yes
6: Change param. (Level 2 S8)
Yes
Default or New Link Acquired ?
No

FIG. 22

FIG. 23

Message Name	Message Type	Opcode Field	Data Field	Description
IDLE	STATUS	0xFF	0x00	EOC transport
UTC	ECHO	0xF0	Same as messaged being UTC'ed	Unable To Comply message

Message Name	Message Type	Opcode Field	Data Field	Description
SNRREQ	COMMAND (READ) and ECHO	0x01	2 MSBs = DS channel #; 9 LSBs = COMMAND: All zeros. ECHO: Specified DS channel SNR in dB, LSB weight = 1/8 dB	Request that VTU-R send SNR data in the return data field
THRPUT	COMMAND (WRITE) and ECHO	0x03	Coded to convey final selected transmission parameters to VTU-R	Indication to VTU-R that rate adaptive startup is complete.
CORERREQ	COMMAND (READ) and ECHO	0x05	COMMAND: All zeros ECHO: Expect VTU-R's CORERR data as unsigned integer = # of errors (saturates at 65,535)	Request that VTU-R send number of errors corrected by RS in the return data field since the last CORERREQ
UCERREQ	COMMAND (READ) and ECHO	0x07	COMMAND: All zeros. ECHO: Expect VTU-R's UCERR data as unsigned integer = # of errors (saturates at 65,535)	Request that VTU-R send number of uncorrectable RS blocks in the return data field since last UCERREQ

FIG. 24

Message Name	Message Type	L1/L2 Class	Opcode Field	Data Field	Description
D_CONST	COMMAND (WRITE) and ECHO	L1	0x28	2 MSBs = DS channel #; 6 LSBs = log2(constel. size)	Request that specified DS chan. # constel. be changed
D_NOM	COMMAND (WRITE) and ECHO	L1	0x34	Indicates which nominal DS symbol rate and center freq. set to use	Select nominal DS symbol rate and center frequency indicated in data field
U_CONST	COMMAND (WRITE) and ECHO	L1	0x98	2 MSBs = US channel #; 6 LSBs = log2(constel. size)	Request that specified US chan. # constel. be changed
U_NOM	COMMAND (WRITE) and ECHO	L1	0xA4	Indicates which nominal US symbol rate and center freq. set to use	Select nominal US symbol rate and center frequency indicated in data field

FIG. 25